

Mandal, A. (2025). Sustainable Nutrition: Balancing Environmental Responsibility and Global Food Demands. *Brainwave: A Multidisciplinary Journal*, 6(2), 1040–1049.

Sustainable Nutrition: Balancing Environmental Responsibility and Global Food Demands

Anal Mandal

*Sadhu Ramchand Murmu University of Jhargram, Jhargram, West Bengal.
Email: 2001analmandal@gmail.com*

Received on: February 15, 2025 | Accepted on: June 23, 2025 | Published on: June 29, 2025

Abstract

With the globe's environmental, economic, and social problems growing, investigation into responsible nutrition is essential. With an emphasis on healthy agricultural methods, environmental effects, food waste management, and legislative structures, this analysis examines the present status of environmentally friendly food systems. The assessment also discusses new developments in food autonomy, dietary habits based on plants, and technology that aims to provide global food security while halting destruction of the environment. Guidelines for moving toward healthier and inclusive nutritional systems are included in the investigation's conclusion.

Keywords: Sustainable food systems, Environmental impacts, Food waste management, Food security, Dietary habits, Ecological preservation, social responsibility.

1. Introduction

The entirety of the alimentary chain, through farming and transportation to eating and trash management, is included in a food system that is environmentally friendly. A comprehensive approach is crucial for preventing global warming, lessening pollution, and guaranteeing that everyone has fair enjoyment of healthy meals. Around a third of all emissions caused by humans come from agri-food frameworks, making them major contributors to global greenhouse gas emissions. Growing crops, shifting the distribution of land, and commodity supply chain operations like processing, packaging, and transportation are some of the steps that contribute to this pollution

[1]. Contributions from worldwide agricultural and food production increased by 10% during 2000 to 16.2 billion tonnes of greenhouse gas similar (Gt CO₂e) through 2022 [2]. Detrimental methods resulting in forest clearing, decreased biodiversity, and erosion of soil exacerbate the ecological impacts of food chains. For instance, trees are frequently destroyed as a consequence of land use development, which raises greenhouse gases and damages habitats [3]. A revolutionary method for dealing with farming that incorporates ecological into all aspects, from manufacture to utilization, is necessary to meet these difficulties. This entails implementing strategies that reduce harmful emissions, advance social justice, and guarantee financial sustainability. A key component of this change is the acceptance of diets made up of plants,

the decrease in trash from agriculture, and the use of ethical farming practices [4]. The study systematically reviews recent discoveries and researches to understand the relationship among Sustainable Nutrition, Environment and Global food demand.

2. Framework for Ecologically Sustainable Agriculture: Balancing Social, Economic, and Ecological Responsibility

According to the theory of ecological farming, present food requirements can be satisfied while endangering the capacity of future generations to provide their requirements. Several interconnected components are included within this the sense that finance, society, and environmental sustainability.

❖ Ecological Sustainability

Agricultural methods that preserve or improve the ecological condition are referred to as ecologically sustainable. This entails lowering pollution, preserving water supplies, and fostering wildlife. Continuous research, for example, has demonstrated that diversifying agricultural techniques like sustainable agriculture and combining can result in notable enhancements in soil fertility, carbon absorption, and biological diversity. These methods improve farming systems' resistance to warmer temperatures while simultaneously reducing environmental damage [5].

❖ Social Sustainability

The objective of social viability is to guarantee that everyone has a means of getting sufficient healthy food and that farming methods improve the welfare of communities. Fair hiring procedures, volunteerism, and equity are highlighted in this aspect of the picture. By creating local food connections and encouraging social participation, innovative social technologies like community-supported

agriculture are essential to changing the food industry [6].

❖ Economic Sustainability

The agricultural technique's long-term viability and ability to maintain livelihoods are guaranteed by economic viability in agribusiness. This entails fostering fair trade, ensuring that food systems are resilient to economic unexpected events, and generating revenue streams for producers and regions. Research has shown that producers can become more profitable by using environmentally conscious farming practices, particularly if they are backed by the right regulations and have access to markets [7].

3. Sustainable Agricultural Practices: Reducing Greenhouse Gas Emissions, Restoring Biodiversity, and Enhancing Water Efficiency

A substantial source to worldwide emissions of greenhouse gases (GHG), agriculture will be responsible for around 11% of all emissions in 2023. This covers pollutants through land-use changes, the use of fertilizers, and the production of crops and animals. Methods of sustainable agriculture including ecological agriculture, ecological agriculture, and capturing carbon are crucial to reducing these effects [8].

❖ Sustainable agriculture & carbon capture

These methods enhance soil condition and environmental tolerance in addition to sequestering energy. Research over a long period has demonstrated, for example, that diversifying agricultural techniques like organic agriculture and combining can result in notable enhancements in the quality of the soil, ecology, and preservation of carbon [9].

❖ **Regeneration of Habitats and Wildlife**

By simulating ecosystems that exist naturally, such networks improve the ecological balance and offer habitats for a variety of animals. Integrated agricultural techniques have been shown to gradually boost biodiversity and ecosystem services [10].

❖ **Productivity in utilizing water & Aquifer Conservation**

Drip irrigation for agriculture and capturing rainwater are two examples of responsible approaches to water management that can be used to cut down on water use and ease the strain on supply of groundwater.

4. Reducing Food Waste: Enhancing Supply Chain Efficiency and Promoting Sustainable Consumption

A significant worldwide concern is the waste of food (FLW), with over one-fifth of all food produced for human use going to waste or disappearing each year. The family level accounts for 60% of this, next to catering services (28%), and retail (12%). This translates to around 1.05 billion tonnes of food, or 132 kg per capita. Nevertheless, food scarcity and malnutrition still affect more than 783 million people globally [11]. FLW has a significant negative influence on our surroundings, accounting for up to 10% of worldwide global warming emissions—nearly five times as much as the aviation industry. Furthermore, agriculture wastes assets like energy, water, and land, which exacerbates climate change and biodiversity loss [12].

A number of technological developments are being made to tackle this and lower FLW:

• **Intelligent Packing:** New developments include independent, stretchy, and battery-free innovative packaging solutions. By extending the lifespan and monitoring food quality using gases sensors along with regulated release processes, these

mechanisms may help cut down on waste and spoiling.

• **Meal Wastage Monitoring Equipment:** Orbisk and other systems use camera systems in kitchens for business to monitor and evaluate the patterns of food waste, providing information that may be used to improve preparing and procedures for inventory and assist in lowering waste.

• **Better Warehousing Practices:** the flavour of food is preserved and expiration is decreased throughout transit and resale thanks to improvements in holding means, such as better conditioning and packaging materials.

To lessen the negative effects of waste from food on society as a whole, these technologies must be put into place in addition to better supply chain management and consumer education about ethical eating. The UN's Sustainable Development Agenda Goal 12.3 calls for global, national, and local cooperation to cut the worldwide consumption of food at the commercial and individual sectors in half by 2030.

5. Global and Local Strategies for Sustainable Food Systems: The Role of SDGs, Policy Initiatives, and Food Sovereignty

A worldwide structure for promoting environmentally friendly agriculture is provided by the Sustainable Development Goals (also known as SDGs) of the UN, with a focus on Goal 2 (Zero Hunger) and Goal 12 (Responsible Consumption and Production). The goals are to end hunger, guarantee food security, enhance dietary habits, and advance ecologically sound agriculture. Through a number of programs, the Food and Agriculture Organization, or FAO, has played a significant role in furthering these goals.

➤ **The Function of the FAO in Encouraging Healthy Agriculture**

In order to accomplish these goals, the FAO's Committee on International Food Security (CFS) has been aggressively advocating for the reform of agri-food systems. In order to combat hunger and malnutrition, the CFS underlined in 2021 the necessity of combined approaches, stressing the significance of coordinating regulations, laws, and financial plans to promote equitable food systems. The "Voluntary Guidelines on Food Systems and Nutrition," which offer recommendations for formulating laws that support wholesome diets and environmentally friendly manufacturing methods, were approved by the CFS [13].

➤ **Strategies for Regional & National Policies**

Massive, intensive agriculture has historically profited from incentives offered through the European Union's Common Agricultural Policy (CAP), which has degraded the natural world. While there are still obstacles in completely matching incentives to environmentally friendly aims, recent measures attempt to reroute funding onto more environmentally conscious practices. Similar to this, countries in Africa such as the Republic of Ghana, Kenya, and South Africa are creating policies that take nutrition into account in order to improve both health and food safety through sustainable food systems [14].

➤ **Community Governance & Food Independence**

The idea of dietary nationalism places a strong emphasis on individuals having access to wholesome, culturally sensitive food that is grown using environmentally friendly and environmentally friendly methods. It

challenges the authority of international businesses in the alimentary production industry and promotes local ownership over alimentary systems, involving land, water, and seed materials. By giving inhabitants more control over their food systems, this strategy aims to ensure that farming satisfies regional need while honouring cultural customs [15].

6. Promoting Sustainable Diets: The Environmental and Health Benefits of Plant-Based Eating and Consumer Education

The substantial advantages that vegan and vegetarian diets offer to the natural world and human wellness have led to increasing acceptance. There is substantial proof from new research that consuming a diet made up of plants has positive environmental effects.

The advantages of eating more plants for sustainability

• **A decrease in combustion of carbon dioxide**

Although producing just seventeen percent of the world's energy, animal agriculture is a significant source of carbon dioxide emissions, making up around 60% of agricultural production. Perhaps the more significant individual measures to address warming temperatures is embracing a vegan diet, which might decrease concerning food carbon dioxide emissions at a greater level [16].

• **Environmental and Water Asset Management**

Compared to diets based on plants, meals made from animals have a substantially larger ecological impact. For example, it takes roughly 15,400 litres of water to produce 1 kilogram of cattle, yet only 322 litters are needed to produce 1 kilogram of veggies. Following a vegan program decreased water use by 54%, according to a 2023 study [17].

- **Forest destruction & Environmental Decline**

Approximately 75% of all the farmland on Earth is used for farming with livestock, mostly for grassland and the production of feed for cattle. A diet dominated by plants could reduce erosion as well as habitat degradation by up to 80% by minimizing the amount of land used for agriculture [18].

- **The importance of knowledge and understanding**

The promotion of ecologically conscious eating practices is greatly aided by educational programs. Initiatives such as "Meatless Mondays" have proven successful in motivating people to consume fewer animal products. Meatless Mondays, for instance, resulted in a 10% decrease in the intake of meat, according to research conducted at the U.S. Coast Guard Academy [19]. Furthermore, in order to enhance the quality of life and lessen adverse environmental effects, worldwide organizations like the EAT-Lancet Conference promote dietary changes toward meals made with plants [20].

7. Innovative Agricultural Technologies and Sustainable Food Alternatives: Reducing Environmental Impact and Enhancing Productivity

The production of nutritious foods is changing as a result of novel farming methods, substitute forms of protein, and technological developments. An updated summary of these advancements, backed by current studies and guidelines, is provided below:

- ❖ **Targeted Farming: Maximizing Resources & Cutting Down on Garbage**
Growers can precisely track and regulate the condition of crops, weather, including

utilization of resources thanks to contemporary tools for farming including satellite visualization, the web IoT and AI. For example, multidimensional camera-equipped unmanned aircraft plus humidity meters can identify shortages of nutrients and adjust spraying agendas, resulting in lower water consumption and greater yields from crops. An example of the increasing advancement in the agricultural sector is a partnership among BITS-Pilani and Punjab Agricultural University (PAU), which focuses on information analysis, satellite knowledge, as well as (AI) to improve farmed sustainability as well as effectiveness [21].

- ❖ **Complementary The protein content was Eco-Friendly Approaches to Farming for Protein**

1. **Flesh Manufactured in Labs** A viable substitute for traditional slaughtering is farmed meat, which is made by cultivating cells from animals in regulated conditions. Research shows that relative with conventional beef, lab-grown meat can have fewer emissions of greenhouse gases, less land use, and less use of water. Nevertheless, the technique is not yet economically feasible at scale, and present manufacturing practices are costly to operate [22].

2. **Protein Based on Insects** Compared to conventional animals; invertebrates such grubs and black army mosquito larvae are lower resource requirements and higher in protein. Enzymes can be feeding decaying matter and turn it into high-quality protein that may be consumed as nourishment for livestock or for human use. New analysis, yet indicates that the ecological benefits of insect protein might not be as great as originally believed, particularly when taking the production and distribution processes into account [23].

❖ **Metropolitan the Agriculture Sector: Developments in horizontal farming**

Crops are grown vertically in layered levels, frequently in regulated indoor spaces. This approach brings food production closer to customers by lowering the demand for agricultural land and enabling its implementation in urban settings. One recent development is electro-agriculture, that allows development in total darkness by converting atmospheric carbon dioxide into molecules of organic material that plants may need through powered by sunlight reaction processes. Furthermore, integrating AI into agricultural systems improves sustainability and food security by automating procedures and optimizing use of resources [24].

8. Fundamentals of Farm Environment: Using Natural & Biological Methods to Improve Soil Infertility, the diversity of life, as well as Stability

Through the integration of ecological concepts into the farming process, ecological agriculture aims to improve soil quality, increase resilience against pests and diseases, and sustain wildlife. This strategy places a strong emphasis on a variety of agricultural methods, the use of environmentally friendly inputs, and a decreased use on artificial nutrients. Sustainable farming goes above simple protection by actively enhancing the general health and aesthetic appeal of farmland via techniques like cover crops, rotational feeding, and zero-till farming. An important part of this model is sustainable agriculture, which avoids chemical fertilizers and emphasizes crop rotation, sustainable components, and soil wellness. Organic gardening offers substantial advantages in the area of soil preservation and diversity, even though the outcomes are frequently shorter than those of standard farming [25].

❖ **Improving the fertility of soils & Conservation through Agro Economics**

To increase long-term viability rural ecology incorporates ecological principles into farming practices. By using these techniques, adaptive ecosystems are produced that can endure adverse conditions and are less reliant on outside inputs. Such findings are supported by recent research. For example, combining it as well as sustainable farming are examples of business diversifying techniques that, eventually, dramatically boost ecological benefits, the environment, and economic sustainability . Following a twenty-year span of diverse methods, they found that biodiversity as well as soil integrity measures increased by up to 2823% based on their review of five decades of evidence through 184 meta-analytic [26].

❖ **Sustainable Agriculture: Going In addition to Preservation**

Sustainable agriculture includes methods that actively improve the surroundings above protection. By lowering the demand for chemical substances and establishing environments for advantageous living things, these methods promote diversification.

Years of study from the Rodale, an Institute has shown that zero-till schemes incorporating planted covers can enhance ground condition and help sequester emissions. According to published studies, these methods boost diversification and resistance versus the effects of changing climates in addition to improving the foundation of soil [27].

❖ **Managing Ecology & Productivity in Organic Production**

The methods used in sustainable agriculture are designed to preserve soil wellness and lessen their negative effects on the planet. The rotation of crops, recycling, and the use of less pesticides are examples of organic practices that improve soil fertility and the sustainability of ecosystems. These advantages are corroborated by a review by Mäder

et al. (2002), which demonstrates that natural farming methods enhance the composition of the soil, boost microbial life, and strengthen storage of water. These developments support cropping techniques' sustainable future [28].

9. Promoting Sustainable Eating and Local Food Systems: The Role of Education and Community-Based Farming

Knowledge is essential to improving society's perspective of sustainability over time. Researchers can promote environmentally conscious eating practices by educating people regarding the effects that their food decisions have on the natural world and their physical well-being [29]. This strategy is in line with the expanding focus on food systems that are sustainable, which seek to generate food in methods that preserve the natural world, make effective use of materials, assist landowners, and improve the standard of living for populations who cultivate it. In order to promote environmentally friendly behaviours and guarantee the stability of local feeding systems—such as neighbourhood greenhouses that are used culinary collectives, as well as community-supported cultivation (CSA) programs—are essential. By enabling personal interaction among farmers and customers, these solutions lower the environmental footprints of food-related delivery while promoting resilient communities. Ultimately also give people the opportunity to consume current, healthy food, something that's crucial for the well-being of everyone, along with helping boost the regional economy. Additionally, lessons that increase knowledge of environmentally friendly agriculture as well as the ecological implications of dietary decisions are frequently incorporated into indigenous food chains [30].

10. Discussion

With between 20 & 38 percent of global greenhouse gas (GHG) emissions, the world's agri-food industry is a significant contributor to climate change, outperforming industries like electricity manufacturing and logistics. Pollution from agricultural and food industries increased by 10% from 2000 to 16.2 billion tonnes of CO₂ equivalent in 2022[31].

❖ Principal Causes of Releases

- **Gas Pollutants:** The main sources of methane, a powerful GHG, are rice cultivation and cattle rearing. About 35% of the emissions of greenhouse gases from the food chain are caused by methane.
- **Agriculture & Destruction:** Growing farms frequently result in deforestation, which raises greenhouse gases and reduces wildlife.
- **Purchasing Operations:** Transport, wrapping, and assembly all have a major impact on outputs. About 5.4% of gases from the global food chain are caused by package solely [32].

❖ Techniques towards Prevention

- **The Acceptance of Organic Plans:** Since foods made from plants often have less of an ecological impact than those from animals, switching to a diet high in plants can help decrease the release of greenhouse gases [33].
- **Nutrition Garbage Cutting:** 8–10% of yearly worldwide releases of greenhouse gases are caused by wasted food and disposal. Emissions can be considerably reduced by putting waste reduction measures into practice [34].
- **environmentally friendly Economic Behaviours:** Methods like the System of Rice

Intensification (SRI), ecological agriculture, and ecological farming have demonstrated effectiveness in lowering toxins and improving soil health.

- **Scientific Improvements:** Using electric-powered farm machinery and integrating neural networks into agricultural operations can maximize resource utilization and reduce carbon dioxide emissions [35].

❖ Obstacles & Things to Think About

- **Financial & Environmental Fairness:** small-scale agricultural producers may need assistance and incur initial expenses when implementing environmentally friendly techniques. It is essential to guarantee fair distribution of assets and capabilities.
- **Government & Organizational Assistance:** To encourage environmentally friendly choices and ease the shift to a low-emission agricultural industry, comprehensive programs and rewards are required [36].

11. Conclusion

Given the growing harm caused by global warming, and worldwide shortages of food, achieving nutritious eating is vitally important. The pressing requirement for a comprehensive overhaul of the whole food structure—from cultivation and processing to consumption and garbage management—has been highlighted by the current investigation. Towards the core of this dilemma are agri-food frameworks, which account for almost one-third of the carbon dioxide emissions caused by people. Woodland loss, erosion of soil, and ineffective logistics networks are examples of inappropriate activities that not only worsen the impact on the environment as well as jeopardize ecological diversity as well as the sustainability of food supplies. Incorporating environmentally friendly ideas into each step of the food supply

chain is necessary for lasting change. It is crucial to implement tactics like switching to a diet made up of plants, reducing garbage from agriculture, and encouraging moral, restorative methods of agriculture. Furthermore, maintaining financial security along with equal opportunity for all has to keep to be at the heart of any structural change. A robust, inclusive, and low-emission food system that benefits humans as well as our surroundings can be created by balancing ethical behaviour alongside the world's food requirements.

In the end, nutritious food concerns because our actions affect habitats, finances, and social structures rather than the food that humans eat. Nous cannot establish a healthy along with sustainably produced eating paradigm without concerted worldwide initiatives, official backing, creation, as well as recognition among consumers.

References

1. FAO. (2021). Food systems account for more than one third of global greenhouse gas emissions. Food and Agriculture Organization of the United Nations.
2. FAO. (2024). Greenhouse gas emissions from agrifood systems. Global, regional and country trends, 2000–2022. Food and Agriculture Organization of the United Nations.
3. En-ROADS. (2023). En-ROADS June 2023: Food and Agriculture. Climate Interactive.
4. Verywell Health. (2023). What Is the Planetary Health Diet? How to Try This Eco-Conscious Eating Pattern.
5. Egli, L., Rüschhoff, J., & Priess, J. (2023). A systematic review of the ecological, social and economic sustainability effects of community-supported agriculture. *Frontiers in Sustainable Food Systems*, 7, 1136866.
6. Raveloaritiana, E., & Wanger, T. C. (2024). Decades matter: Agricultural diversification increases financial profitability, biodiversity, and ecosystem services over time.

7. Schwarz, J.-M. (2024). Sustainable food systems: Integrating environmental, economic, and social dimensions for future food security. *Journal of Food Science and Nutrition*, 7(4), 250.
8. Food and Agriculture Organization (FAO). (2024). Greenhouse gas emissions from agrifood systems. Global, regional and country trends, 2000–2022.
9. Raveloaritiana, E., & Wanger, T. C. (2024). Decades matter: Agricultural diversification increases financial profitability, biodiversity, and ecosystem services over time.
10. United Nations Educational, Scientific and Cultural Organization (UNESCO). (2022). UN World Water Development Report 2022: Groundwater – Making the invisible visible.
11. United Nations Environment Programme (UNEP). (2024). Food Waste Index Report 2024.
12. Drishti IAS. (2024). Food Waste Index Report 2024.
13. Food and Agriculture Organization (FAO). (2021). Committee on World Food Security (CFS) kicks off with a call for agri-food systems transformation.
14. Food and Agriculture Organization (FAO). (2020). A Food Systems Approach to Food Security and Nutrition | ThinkTwenty (T20) India 2023.
15. Windfuhr, M., & Jonsen, J. (2005). Food Sovereignty. Practical Action Publishing.
16. Carrington, D. (2023, July 20). Vegan diet massively cuts environmental damage, study shows. *The Guardian*.
17. Springmann, M., et al. (2018). Options for keeping the food system within environmental limits. *Nature*.
18. Van Dooren, C., et al. (2014). Exploring the environmental impacts of dietary recommendations. *Food Policy*, 44, 1-10.
19. Velasco-Muñoz, J. F. (2023). Sustainable water uses in agriculture: A review of worldwide research. *Environmental Science & Policy*, 135, 1-12.
20. Pimentel, D., & Pimentel, M. (2003). Sustainability of meat-based and plant-based diets and the environment. *The American Journal of Clinical Nutrition*, 78(3), 660S-663S.
21. Chowdhury, H., Paul Argha, D. B., & Ahmed, M. A. (2023). Artificial Intelligence in Sustainable Vertical Farming.
22. Department for Environment, Food & Rural Affairs (DEFRA). (2025, May 27). Hold the insect burger: eating bugs is bad for the climate.
23. Hajjaji, Y., Alzahem, A., Boulila, W., Farah, I. R., & Koubaa, A. (2023). Sustainable Palm Tree Farming: Leveraging IoT and Multi-Modal Data for Early Detection and Mapping of Red Palm Weevil.
24. Stein, E. W. (2021). The Transformative Environmental Effects Large-Scale Indoor Farming May Have on Air, Water, and Soil.
25. Altieri, M. A. (2009). *Agroecology: The science of sustainable agriculture* (2nd ed.). CRC Press.
26. Raveloaritiana, E., & Wanger, T. C. (2024). Decades matter: Agricultural diversification increases financial profitability, biodiversity, and ecosystem services over time.
27. Rodale Institute. (2025). The Rodale Institute.
28. Mäder, P., Fließbach, A., Dubois, D., Gunst, L., Fried, P., & Niggli, U. (2002). Soil fertility and biodiversity in organic farming. *Science*, 296(5573), 1694–1697.
29. Hinrichs, C. C. (2000). Embeddedness and local food systems: Notes on two types of direct agricultural market. *Journal of Rural Studies*, 16(3), 295–303.
30. Vermeulen, S. J., Campbell, B. M., & Ingram, J. S. I. (2012). Climate change and food systems. *Annual Review of Environment and Resources*, 37, 195–222.
31. Center for Science and Environment. (2022). The global food system and our food practices account for 21–37 per cent of the world’s annual greenhouse gas emissions. practices-account-for-21-37-per-cent-of-the-world-s-11184
32. Food and Agriculture Organization of the United Nations. (2023). Greenhouse gas emissions from agrifood systems. Global, regional and country trends, 2000–2022.

33. Food and Agriculture Organization of the United Nations. (2023). Food systems account for more than one third of global greenhouse gas emissions.
34. Food and Agriculture Organization of the United Nations. (2023). Food loss and waste account for 8–10% of annual global greenhouse gas emissions; cost USD 1 trillion annually.
35. Varma, P. (2019). Adoption and the impact of system of rice intensification on rice yields and household income: An analysis for India. *Applied Economics*.
36. Chowdhury, H., Paul Argha, D. B., & Ahmed, M. A. (2023). Artificial Intelligence in Sustainable Vertical Farming.

Contributor

Anal Mandal

PG Student, Department of Nutrition and Public Health, Sadhu Ramchand Murmu University of Jhargram, West Bengal, India.

Email: 2001analmandal@gmail.com